STANDARD METHOD FOR PREPARING AND DETERMINING THE DENSITY OF HOT MIX ASPHALT (HMA) SPECIMENS BY MEANS OF THE SHRP GYRATORY COMPACTOR

AASHTO TP 4

GLOSSARY

Corrected relative density (% G_{mmx}) -- the density of a specimen determined at x number of gyrations and expressed as a percentage of the maximum theoretical specific gravity of the mixture.

N-initial (N_{ini}) -- the initial number of gyrations used to analyze the early densification properties of HMA during construction.

N-design (N_{des}) -- the design number of gyrations used for design of the HMA.

N-maximum (N_{max}) -- the maximum number of gyrations used to assess the densification properties of the HMA after several years in service.

SCOPE

Compacted samples of HMA are used to determine the volumetric and mechanical properties of the mixture during the mix design phase and for QC/QA during construction. These volumetric and/or mechanical properties are then evaluated to select a mix design or control the mixture during production. The specimens produced with the gyratory compactor simulated the density, aggregate orientation and structural characteristics of the mixture in the pavement.

The gyratory compactor is used to prepare specimens for later analysis of the volumetric properties of the mixture, evaluation of mixture densification properties, evaluation of moisture sensitivity, field quality control, or other testing purposes.

The test method explains the method of compacting samples of HMA and determining their percent compaction using the SHRP gyratory compactor. This procedure may be used with laboratory fabricated specimens, as in the mix design process, or with plant-mixed material during construction.

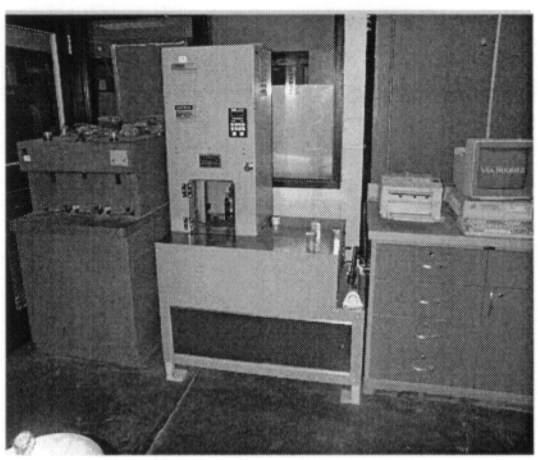
SUMMARY OF PROCEDURE

Apparatus

- Superpave Gyratory Compactor, including a device for measuring and recording the height of the specimen throughout the compaction process. The compactor may also include a printer or a computer and software for collecting and printing the data.
- Specimen molds
- Thermometer, armored, glass, or dial-type with metal stems and a range of 10 to 232°C (50 to 450°F)
- Balance, general purpose class G5 (AASHTO M 231)
- Oven, thermostatically controlled to ± 3°C (± 5°F)
- Calibration equipment recommended by compactor manufacturer
- Safety equipment: insulated gloves, long sleeves, etc.
- Miscellaneous equipment: paper disks, lubricating materials recommended by compactor manufacturer, scoop or trowel for moving mixture, funnel or other device for ease of loading mixture into mold (optional).

Calibration

The means of calibrating the gyratory compactor varies with different manufacturers. Refer to the operation manual of the particular brand and model of gryatory available for use. ITM 910 should be followed for the proper recordation of calibration data.



Gyratory Compactor

Sample Preparation

Samples for compaction in the gyratory may be obtained in one of two ways; mixture may be prepared in the laboratory or plant-mixed material may be obtained from the pavement or trucks.

For the determination of volumetric properties for mix design or quality control, a finished specimen height of 115 ± 5 mm is desired. If a target air void level is desired, the batch weights must be varied to provide the desired specimen height at a specified air void content; samples are then compacted to the specified height rather than a fixed number of gyrations.

Laboratory Prepared Materials

Preparing samples of mixture in the laboratory requires batching the aggregates, mixing in the proper amount of binder, conditioning the prepared mixture, heating the mixture to compaction temperature and compacting the specimen. The steps involved in preparing the mixture in the laboratory are as follows:

1. Weigh out the appropriate amounts of the required aggregate size fractions and combine in a bowl to the proper batch weight. Typically, a batch weight of 4500 - 4700 grams of aggregate will provide enough material for a finished specimen height of 115 ± 5 mm, if the combined aggregate specific gravity is between 2.55 - 2.70.

2. Heat the binder and the combined aggregate in an oven to the appropriate mixing temperature for the binder to be used. This temperature can be determined from an equi-viscous temperature chart or may be provided by the binder supplier. The appropriate temperature range for mixing is defined as the range of temperatures that produces a viscosity of 170 ± 20 mm^2/s for the unaged binder. This ensures that the binder is fluid enough to coat the aggregate particles. Some modified binders do not follow these temperature-viscosity relationships and the manufacturer's recommendations should be followed.

3. Place the heated aggregate in the mixing bowl and thoroughly dry mix the sample. Make a crater in the center of the aggregate in the bowl and weigh in the required amount of binder. Begin mixing immediately. A mechanical mixer may be used.

4. Determine the proper compaction temperature range for the binder used. This is defined as the range of temperatures that yields a binder viscosity of approximately 280 ± 30 mm^2/s. Modified binders may not conform to these mixing and compactions temperatures, and the manufacturer's recommendations should be followed.

5. After mixing, spread the loose mixture in a flat, shallow pan and short term condition the mixture as detailed in AASHTO PP 2.

6. Place the compaction mold and base plate in an oven to preheat at the required compaction temperature for a period of 30 to 60 minutes prior to the start of compaction.

7. Following the short term conditioning period, bring the mixture to the proper compaction temperature, if different from the conditioning temperature, by placing it in another oven at the compaction temperature for up to 30 minutes.

8. After the mixture comes to the proper compaction temperature, proceed with compaction in the gyratory compactor.

Plant-Mixed Materials

When plant-mixed materials are sampled from the roadway or truck, no short term aging is required. Place the material in an oven at the compaction temperature and bring the mixture to the proper temperature by careful, uniform heating. The mix should be stirred periodically. In general, the shortest heating time that will bring the mixture to the compaction temperature is preferred. When the compaction temperature has been reached, proceed with specimen compaction.

Compaction Procedure

Once the mixture sample has reached the proper compaction temperature, it is compacted in the gyratory compactor. For most purposes, the finished specimens will be used to calculate volumetric properties and the specimens will be compacted to a fixed number of gyrations. When preparing specimens for testing under AASHTO T 283 or in Superpave mix analysis, specimens may be compacted to a fixed height to produce a specified air void content.

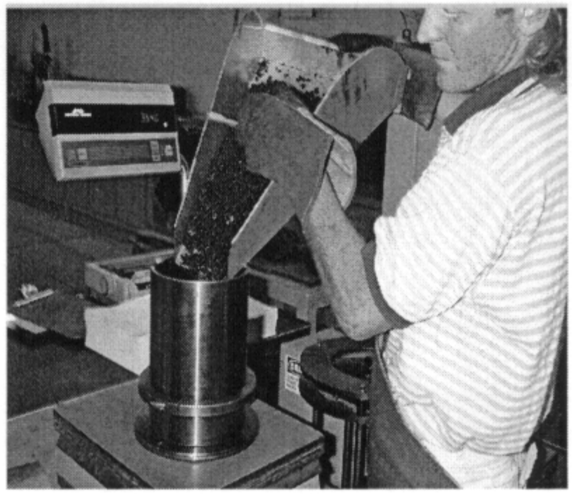
The procedure to compact to a fixed number of gyrations is as follows:

1. Ensure that the gyratory compactor has been turned on and allowed to warm up for the time recommended by the manufacturer. Verify all settings for angle, pressure and number of gyrations.

2. Verify the height recording device is turned on and is reading in the proper units.

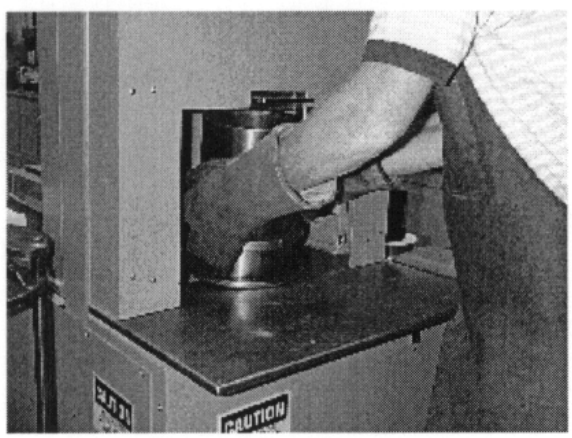
3. When the compaction temperature has been reached, remove the mold and base plate from the oven. Put the base plate in position in the bold and place a paper disk in the bottom of the mold.

4. Charge the mixture into the mold in one lift. A funnel or other device may be used to place the mixture into the mold. Take care to avoid segregating the mix in the mold, but work quickly so that the mixture does not cool excessively during loading. Level the mix in the mold and place a paper disk on top.



Pouring Mix into the Mold

5. Place the mold in the gyratory as per manufacturer's recommendations. (Some gyratories allow charging the mold with mix after the mold has been positioned in the compactor.) Lubricate the mold or gyratory parts as recommended by the manufacturer.

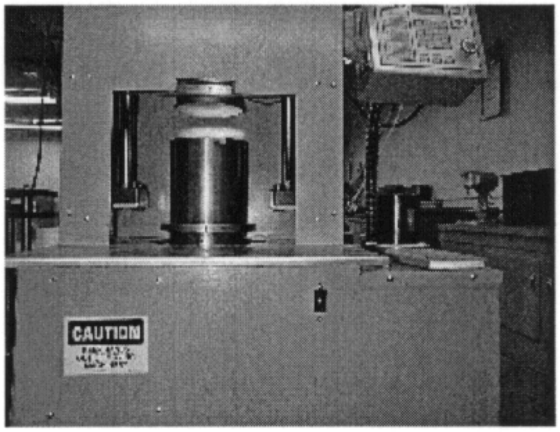


Placing Mold into the Compactor

6. Apply the load to the mixture in the mold according to manufacturer's recommendations. The pressure applied should be 600 ± 18 kPa.

7. Apply gyratory angle of 1.25° ± 0.02° to the specimen.

8. Input the desired number of gyrations and start the compaction process.



Mold in Compactor Ready to Test

9. The gyratory will stop automatically when the specified number of gryations has been reached. Remove the angle from the specimen and raise the loading ram if needed (this is done automatically on some gryatory compactors).

10. Remove the mold from the compactor, if required, and extrude the specimen from the mold. Take care not to distort the specimen when removing the specimen from the mold. A cooling period of 5 to 10 minutes may be necessary with some mixtures; a fan may help speed the cooling process. Remove the paper disks while the specimen is still warm to avoid excessive sticking.

Density Procedure

When compacting specimens for the determination of volumetric properties for mix design or QC/QA, it is necessary to determine the specimen height, bulk specific gravity, and mixture maximum theoretical specific gravity. This requires the following additional steps:

1. Prepare a loose sample of the same mixture and determine the maximum theoretical specific gravity (G_{mm}) in accordance with AASHTO T 209.

2. Using the gyratory's height recording system, record the height of the specimen to the nearest 0.1 mm after each gryation.

3. Measure and record the mass of the compacted specimen to the nearest 1 g. Determine the bulk specific gravity (G_{mb}) of the compacted specimen in accordance with AASHTO T 166.

Density Calculations

Using the measured bulk specific gravity of the final compacted specimen and the measured maximum specific gravity of a loose sample of the mixture, and knowing the height of the specimen at different numbers of gyrations, it is possible to calculate the corrected relative density of the specimen. The corrected relative density at any number of gyrations is expressed as a percentage of the maximum theoretical specific gravity for the mix. This allows a determination of the air void content of the specimen at any number of gyrations.

Calculate the corrected relative density of the specimen at any number of gyrations as follows:

$$\%G_{mmx} = \frac{G_{mb} h_m}{G_{mm} h_x} \text{ x } 100$$

where: $\% G_{mmx}$ = Corrected relative density expressed as a percentage of the maximum theoretical specific gravity

G_{mb} = Bulk specific gravity of the extruded specimen (determined using AASHTO T 166)

G_{mm} = Maximum theoretical specific gravity of the mixture (determined according to AASHTO T 209)

h_m = Height of the extruded specimen in millimeters

h_x = Height of the specific during compaction at x gyrations, in millimeters

Report the relative density, $\% G_{mmx}$, to the nearest 0.1 percent.

Example:

Given: G_{mb}, measured bulk specific gravity = 2.369
G_{mm}, maximum theoretical specific gravity = 2.403
h_m, height of extruded specimen = 117.5 mm

Calculate $\% G_{mmx}$ at N_{ini} = 8, h_8 = 135.4 mm
N_{des} = 109, h_{109} = 119.4 mm
N_{max} = 174, h_{174} = 117.5 mm

$\% G_{mm8}$ = (2.369 x 117.5 mm/2.403 x 135.4 mm) x 100% = 85.6%
$\% G_{mm109}$ = (2.369 x 117.5 mm/2.403 x 119.4 mm) x 100% = 95.3%
$\% G_{mm174}$ = (2.369 x 117.5 mm/2.403 x 117.5 mm) x 100% = 98.6%